Cookbook for
Energy Conservation Measures

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Introduction

California's public schools, like all consumers of power, are being hit hard by increasing costs for electricity and natural gas. To reduce the risk of power outages, the most important thing in the short term is to reduce demand for electricity and use energy more efficiently. According to a survey conducted by the California Association of School Business Officials in 2001, 92 percent of responding school districts regard rising utility costs to be a serious to severe problem and 40 percent of those responding indicated that they expect gas and electric bills to deplete reserves. In response, to the energy crisis in California, the State Allocation Board (SAB) requested that the Office of Public School Construction (OPSC) determine what could be done to encourage school districts to develop energy efficient projects. In addition, it was requested that an analysis of energy conservation measures relating to school construction projects in the School Facility Program (SFP). Specifically, an analysis that provides the following:

1. *How much beyond Title 24 energy requirements would a district/architect have to design into a new construction/modernization project to make a significant difference?*

2. *How can it (energy savings) be measured? For instance if the district/architect does all the right things, what amount of kilowatts can be saved?*

3. *What are the short and long-term activities that will result in significant savings?*

Executive Summary

The OPSC in researching and preparing this report realizes that there are many products and methodologies that school districts could use to design more energy efficient schools and modernization of existing facilities. The majority of this information and analysis is described under the short-term and long-term activities that could be implemented to reduce energy consumption and reduce costs. Although it is not discussed in this report there is a positive impact to the environment when energy saving activities occur.

Using a variety of sources, this report will provide general energy efficiency techniques and methodologies that could be reasonably implemented in school construction that have an immediate effect on energy savings and costs. For instance, the following methods could be implemented by school districts immediately in classrooms and in administrative offices with no additional costs to school districts, thereby reducing demand and cutting energy costs:

- Turn off all unnecessary lights, especially in unused offices, classrooms, and conference rooms and turn down remaining lighting levels where possible.
- Set computers, monitors, printers, copiers, and other business equipment to energy saving feature, and turn them off at the end of the day.
- Minimize energy usage during peak demand hours from 5:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The major peaks occur from 12 noon to 6 p.m. during normal school hours. The energy use during this period can be reduced by "load shedding" thereby reducing the demand at the time the State needs it the most.
- Use laptop computers when possible—they consume 90 percent less energy than standard computers.
- Use inkjet printers (on print jobs not requiring highest quality)—they consume 90 percent less energy than laser printers.
- Use e-mail instead of sending memorandums and faxing documents.

- During the heating season, turn thermostats down to 68 degrees or below. Reduce settings to 55 degrees at the end of the day. (For each 1 degree, saves up to 5 percent on your heating costs.) Turn thermostats up to 76 degrees during the cooling season.
- Clean or replace your furnace and air-conditioner filters.

A main source of information was from the California Energy Commission (CEC). The OPSC contacted the CEC to discuss ways school districts can achieve significant cost savings by implementing energy conservation methods or products. The CEC states that one of the biggest strains on electrical grid, is the use of air-conditioning. Key strategies for reducing electricity use for space cooling that proved cost-effective are:

- Reduction of solar heat gains through windows and ceilings
- Improved duct system efficiency
- Improving the installed efficiency of air conditioning equipment

The CEC suggested a variety of current and future methodologies and technology that would provide measurable cost savings. Technology and methodologies such as:

- Daylighting in classrooms (use of sunlight in lieu of conventional power)
- Adding controls or sensors (to shut off energy usage when no one is present)
- Adding a rheostat (to control watt usage)
- Adding switches that minimize light usage when possible (instead of turning off all lights)
- Higher efficiency rated heating and air-conditioning unit

- Updated ventilation
- Higher rated insulation
- Double or triple paned windows or low transmission tinted glass
- Solar energy (passive and photo voltaic)
- Wind power (wind turbines)
- Geothermal power

At the February 28, 2001 SAB meeting the Board acepted this report and directed the OPSC to track energy conservation legislation and report to the Board.

To further the energy efficiency and conservation agenda, on September 6, 2000, Governor Gray Davis signed emergency legislation Assembly Bill (AB) 970, the California Energy Security and Reliability Act of 2000. One of the AB 970 mandates was to adopt and implement amendments to Title 24, Part 6 of the California Code of Regulations, the energy efficiency standards for residential and nonresidential buildings. The directive for the building standards was to incorporate cost effective building energy efficiency measures that would reduce electricity demand in hot weather (usually over 100 degrees) and provided for more efficient use of electricity. AB 970 mandated that the CEC adopt and implement the new standards by June 1, 2001 (or on the next feasibility date thereafter). The CEC anticipates that the proposed changes to Title 24, Part 6 requirements will be extremely effective in reducing the demand for energy (*see Appendix A: Proposed Changes to Title 24, Part 6, The Nonresidential Building Standards, page 15*).

Issues/Analysis

1. *How much beyond Title 24 energy requirements would a district/architect have to design into a new construction/modernization project to make a significant difference?*

   The CEC has stated that designing a project that would result in 20 to 25 percent energy savings would generate significant energy cost savings to school districts. However, the construction costs associated with building to a higher energy efficiency standard could also increase significantly depending on the level of energy savings desired. This could be achieved by the combination of the installation of energy efficient equipment, materials, or systems that exceed current Title 24 energy standards as previously discussed in the Executive Summary. As previously mentioned, in order to incorporate energy conservation products or materials into a facility will generally increase the cost of construction, but the energy savings that result will offset some or all of the higher construction costs. Depending on the energy payback period, the energy savings can be up to a 100 percent profit for a school district.

2. *How can it (energy savings) be measured? For instance if the district/architect does all the right things, what amount of kilowatts can be saved?*

   The OPSC does not have the technical expertise to do a comprehensive cost/benefit analysis. However, to measure the effectiveness and the cost of the energy conservation product or method, an architect or a licensed energy consultant could prepare a life-cycle analysis cost comparison of the costs and benefits of a proposed design feature integrating alternative energy measures into a proposed SFP project. An energy model of the existing building would be prepared using energy audit data about the building, and would be used as the basis for preparing base case (a project with conventional energy measures) and proposed measure models. The result of this model will be compared to the previous 12 months of energy use billing data for the site (both gas and electric). Measurements from the base case would be derived by reviewing fixed measures (such as insulation), continuing through equipment efficiency measures (such as chillers), and concluding with controls for operating that equipment.

To demonstrate kilowatt savings a school district could replace incandescent lighting with compact fluorescent lamps (CFL) with an electric ballast. CFL's are simply a miniature version of full-sized fluorescent lamps. CFL's typically use 60 to 75 percent less energy than the incandescent lights they replace. Efficiency ranges from 25 to 75 lumens per watt (measurement of lamp efficiency). This is substantially greater than incandescent lamps, which range form 5 to 15 lumens per watt. The higher costs of a CFL are offset by lower operating costs. A CFL will use 1/3 the watts of energy to produce. A comparable amount of light in an incandescent light (i.e., 20 watts of energy produces 60 watts of comparable light in an incandescent light). Further CFL's last longer than incandescent lights and achieve maximum savings when they operate more than 2,000 hours per year. Moreover, the PG&E states that using fluorescent lamps will produce a payback periods that range from zero to 8.8 years (average 1.7 years) depending upon the type of light fixture and operating hours.[1]

Note: A kWh is equal to one thousand watt-hours of energy

3. What are the short and long-term activities that will result in significant savings?

Short-Term Activities

The following are short-term activities that would reduce our demand for electricity, use energy more efficiently, and produce energy savings. Some of these methods will require a school district to expend modest funds to implement:

Daylighting… Daylighting has a major impact on a building's functionality from many perspective-not only on energy costs associated with illumination and space conditioning, but it also may enhance the building's comfort, ambiance, and the effectiveness and productivity of its occupants. The technique of Daylighting, which is using natural light instead of electricity, can reduce your daily consumption by 100 percent. In

[1] Pacific Gas and Electric Company, *A Guide to Reducing Energy Use Through the Use of Compact Fluorescent Lamps*

addition, the Pacific Gas & Electric (PG&E) reports that kids taught in classrooms illuminated by natural light achieve significant progress gains in math and English with scores 7–16 percent higher than those in classrooms with poor natural light.

For example, energy savings that could be achieved by turning off 100 incandescent lamps @ 60 watts each for eight hours results in the following savings:

$$\frac{100 \times 60 \text{ watts} \times 8 \text{ hours}}{1{,}000 \text{ w/kw}} = 48 \text{ kilowatts saved} \times \$0.01^{(\text{Footnote 2})} \text{ per kWh} = \$0.48 \text{ savings per day}$$

Note: A kWh is equal to one thousand watt-hours of energy

Install a programmable thermostat… Research shows that by turning back a thermostat 10 to 15 degrees for eight hours a day can save 15 percent a year on heating and cooling bill. Installing a programmable thermostat will allow the users to set the temperature (lower) and have the unit used during appropriate times only, thereby achieving cost savings by only using energy when it is needed.

[2] Pacific Gas and Electric Company, www.pge.com/003_save_energy/

Weatherproof windows and doors… Excess leakage in windows and doors can increase heating and cooling bills by 30 percent and reduce fire safety. Caulking and weather-stripping, along with other products including plastic window-well covers can make a significant energy savings difference.

Seal and insulate ductwork… The Department of Energy has indicated that a typical duct systems lose 25 to 40 percent of the heating or cooling energy put out by the central heating and cooling unit through transmission of the heat or cold. The PG&E recommend insulating ducting with R-6 material. Specifically, ducting units made out of metal drains heat from the warm air travelling through the ducts. Therefore, replacing metal ducting with alternative materials will improve heating efficiency.

Insulate water heater and pipes… About 15 to 20 percent of energy expense goes for heating water. Wrapping both the water heating and pipes with insulated wraps will improve the efficiency of the water heater and reduce operating costs by up to 15 percent.

Rethink lighting systems… Lighting accounts for 40 percent of commercial energy use. Upgrading lamps are extremely cost-effective. Energy efficient equipment can reduce lighting costs by 30 percent. Install motion sensing fixtures and timers for inside and outside lights to control lighting in frequently unoccupied areas. Florescent fixtures and bulbs provide light using a fraction of the energy and last six to 10 times longer than incandescent bulbs. In addition, new Energy Star[3] fixtures use up to 75 percent less energy than standard fixtures yet gives you the same warm light as incandescent lighting.

Clean light fixtures… Clean lighting fixtures each year to maintain designed lighting levels. The dust and dirt accumulation from one year could reduce light efficiency by 44 percent.

[3] Energy Star is a registered trademark and the symbol for energy efficiency. It is a label created by the U.S. Environmental Protection Agency and U.S. Department of Energy to help consumers save money and prevent air pollution.

Long-Term Activities

There are many long-term solutions that could assist school districts in saving energy and reducing the costs to operate their facilities. Many of these suggestions require school districts to invest little money to implement and others such as solar and wind technologies that are not mass-produced will require significant capital outlay for the up front costs. However, implementing several of the suggestions listed below could result in generous savings over the long term. The following are long-term activities that would reduce energy usage and produce energy savings:

Improve your insulation… The investment in insulating products can usually be restored through energy savings in a short period of time. By increasing the R-value (resistance value) of the insulation the greater the insulating power and reduction of the loss of heat. The Sacramento Municipal Utility District (SMUD) recommends R-30 in ceilings and R-11 in walls. Insulating raised floors with R-19 will assist in reducing the amount of heat lost.

Update your windows and doors… Installing Energy Star-labeled windows and doors can significantly effect how much money is saved every year. These products are twice as efficient as the average windows manufactured just 10 years ago. Energy Star products can help cut heating and cooling costs by up to 15 percent. Replacing clear windows with low transmission tinted glass, or glass with insulated spandrel panels is another method that would reduce energy usage.

The National Fenestration Rating Council (NFRC) has developed a rating system and energy information labels to help consumers better analyze their choices. In California, energy codes require NFRC certification as evidence of code compliance. The label lists characteristics such as whole-window U-factor, solar heat gain coefficient (SHGC), visible transmittance (VT), and air leakage.

Replace your water heater… Gas heaters more than 10 years old probably have efficiency rating of no higher than 50 percent. Look for water heaters with the highest energy factor (EF).

Choose an efficient heater… Heating and cooling accounts for the majority of the energy bill each year. Look for the Federal Trade Commission Energy Guide on each unit that will show the efficiency rating for gas and oil-based furnaces and boilers. In addition, Energy Star furnaces have 90 rating or greater energy efficiency (the higher the number the more energy efficient).

Modify your landscaping… Planting deciduous varieties of trees, such as oak or maple planted on the south and on the west will help keep buildings cool in the summer and allow sun to shine in the windows in the winter. Shade trees will save you up to 40 percent on your summer cooling costs when the trees mature. The SMUD offers free trees through their Shade Tree program.

Solar Power… Solar water heating systems work by gathering the heat from the sun and using it to heat water. Heat is transferred from the collector (usually mounted on the roof) to the domestic water supply storage tank. These two main components are found in all solar water heating systems. There are two types of solar systems:

Passive Systems – use no electronic controls or pumps to move water from the collector to the storage tank.

Active Systems – use one or more pumps operated by an electronic controller to circulate fluid between the collector and the storage tank.

Solar power via photovoltaic cells are another option that would allow school districts to produce all the energy that they need from the sun and would eliminate dependency on municipal sources. In addition, solar power can be saved for future use. Many utility companies offer reimbursement to business, and residential customers who install solar panels. Further, since many schools are closed during the summer, the energy derived from photo voltaic cells could be sold to the energy grid (when the state most needs it) generating zero utility bills and additional funding for the school district.

Wind Power... Wind turbines are another method that would allow a school district to generate its own energy. A wind turbine technology uses a rotor to capture the wind and produce electric output. The machines power curve can actually provide a crude indication of the annual energy output.

For example, by calculating the percentage of the rated power (RP) produced at the average wind speed, one can arrive at a rough capacity factor (RCF) for the wind turbine at a site. Multiplying the rated power output by the RCF by the number of hours in a year will provide a very crude annual energy production. For example, for a 100kW turbine producing 20 kW at an average wind speed of 15 mph, the calculation would be:

100 kW (RP) $\times$ 0.20 (RCF) = 20kW $\times$ 8,760 hours = 175,200 kWh[(Footnote 4)] in energy production

Geothermal... A geothermal system transfers the earth's heat, which remains at a fairly constant temperature at this level, through piping installed under the ground, into a house or building. In the winter, this piping draws warmth from the earth. A water-based solution circulating through the pipes carries that warmth to a heat pump. That pump then circulates the heat into the rest of the building through air ducts. In the summer, the process is reversed. Hot air inside the building is drawn back into the piping in the ground outside. The system can use some of that interior heat in the summer to provide hot water.

Geothermal systems are praised for not burning fossil fuels, running on a small amount of electricity and drastically reducing monthly utility bills. A downside is the installation cost, which can average $6,000 to $10,000 for a new home and could be twice that for an older home.[5]

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[4] American Wind Energy Association at www.awea.org/faq/basicen.html

[5] *Sacramento Bee*, February 20, 2001, An Earthy (but costly) Energy Fix: Geothermal, page B1

Additional Information

In an effort to help school districts be as energy efficient as possible, the California Department of Education (CDE) and the Office of the Secretary for Education have prepared the following information to assist you in planning:

- Immediately develop an emergency action plan to address power outages to schools during and after school operations.
- Contact your local fire, police and utility providers and determine how they intend to respond to rolling black-outs. Coordinate your emergency plans with them.
- Develop a local school board energy efficiency policy that defines the specifics of your district's action plan, and how parents, staff, teachers and students will be involved.
- Review all operational schedules for high-energy use equipment and ensure that energy use is minimized during peak hours of 5 a.m. to 9 a.m. and 4 p.m. to 7 p.m.
- Update your preventive maintenance schedule on emergency lighting, generators, exit lighting, and other safety-related equipment.
- Consider the immediate and long-term impact of high energy fees on your district budget.

Maintenance and Operations

- Review all operational schedules for high-energy use equipment and ensure that energy use is minimized.
- Consult with local utilities to determine any grants or cost reduction incentive programs available to your district for the type of equipment you operate (*see Appendix D: School District Energy Conservation Financing, page 19*).
- Evaluate the operational procedures for the night operational staff and determine if energy efficient schedules or procedures can be developed and implemented.
- Ensure all night shift personnel have access to flashlights and other necessary equipment in the event of an interruption of power.
- Update your preventive maintenance schedule on emergency lighting, generators, exit lighting, and other safety-related equipment.
- Direct staff to turn off all lights and equipment not in use during day and night operations.
- Ensure staff knows and understands what safety, health and sanitary facilities will be interrupted if a rolling blackout hits the district, i.e., drinking fountains, water pressure to flush toilets, fire protection systems, HVAC systems (cooling and heating), telephone and emergency communications (internal and external).
- Set kilns to fire ceramic projects after midnight to reduce peak electrical loads, if possible. Kilns in most schools are among the highest energy use devices in the classrooms.
- Turn off one bank of lights closest to the windows during daylight operations.

Also included in this report are several resources to assist school districts in finding additional information on energy products, training, and other funding sources for energy conservation projects. These are outlined in Appendices B through E, pages 17–20.

Sources

The OPSC relied primarily on information from the previous state school building programs, CEC, and other sources relating to energy conservation. The OPSC used the following resources:

- Sacramento Municipal Utility District (SMUD)
- Pacific Gas and Electric Company (PG&E)
- Department of General Services Web site www.energy.dgs.ca.gov
- California Department of Education/State Superintendent of Public Instruction
- Home Depot Web site at www.homedepot.com
- Guidebook, *Energy Conservation Program*, Office of Public School Construction
- *Guidebook For Energy Conservation Projects For Supplemental Funding,* Office of Public School Construction, (Leroy F. Greene Lease-Purchase Law of 1976)
- Department of Energy
- California School Board Association
- American Wind Energy Association

Appendix A: Changes to Title 24, Part 6, The Nonresidential Building Standards

After review and analysis, the CEC proposed new measures into Title 24, Part 6 to assist California in cutting its electrical demand and reducing of critical air pollutants. These proposed efficiency changes were selected to ensure the maximum feasible reductions in wasteful, uneconomic, inefficient, or unnecessary consumption of electricity. The CEC states that these improvements will affect an estimated 109,0000 homes and 156 million square feet of nonresidential construction in 2001.[1] Projections for 2002 and future years indicate higher expected annual construction rates.[2] It is anticipated that peak demand savings from these proposed changes will be approximately at 150 MW and the total annual savings in electricity use are estimate at 548 GWh for 2001.[3]

The following is a listing of the proposed changes to Title 24, Part 6, which are proposed to be effective June 1, 2001:

- Adopt measures form ASRAE 90.1 that are more efficient than 1998 Title 24, Part 6
- Improve fenestration (window) U-value and SHGC performance requirements
- Reduce lighting power densities for some building spaces
- Remove blanket exemption for bi-level switching when occupancy sensors or automatic controls are installed and for buildings smaller than 5,000 square feet
- Establish requirement for exterior lighting efficiency
- Delete lumen maintenance control credits
- Allow trade-offs for using higher efficiency cooling systems instead of air-side economizers
- Limit the types of controls used on air-side economizers

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[1] Cited from the California Energy Commission's Web site at www.energy.ca.gov/reports/2001-01-04_400-01-007.PDF

[2] Construction Industry Research Board

[3] Cited from the California Energy Commission's Web site www.energy.ca.gov/reports/2001-01-04_400-01-007.PDF

- Increase efficiency requirement for space conditioning and water heating equipment
- Establish compliance credit for "cool roofs"
- Explicitly require protection for duct and pipe insulation installed exterior to buildings
- Require rating and labeling for site-built fenestration in large buildings
- Require demand control ventilation for assembly occupancies
- Clarify lighten compliance requirement for open offices with furniture-based lighting
- Establish compliance credit for duct sealing and insulation of package rooftop HVAC systems

Appendix B: Training and Education

PG&E Savings By Design Program… Encourages high performance non-residential building design and construction to improve building comfort and efficiency. This program is sponsored by three of California's largest utilities under the auspices of the Public Utilities Commission. For more information visit PG&E's Web site at www.pge.com.

SMUD's Greenergy Program… Is designed for SMUD customers who want to decrease the reliance on coal-fire and nuclear generation facilities for electricity. SMUD matches 100 percent of energy needs with purchases of renewable resources for use on the SMUD power system, resources such as geothermal steam and biomass gas.

California School Board Association (CSBA) SmartAudit Program… The SmartAudit program provides a review of utility bills to make sure school districts and county offices of education are being treated fairly and are getting what they pay for with no additional charges. Access the Web site for more information at www.csba.org.

Appendix C: Equipment and Other Utility Rebates

PG&E 2002 Express Efficiency Program… Offers rebates to help businesses reduce energy use without sacrificing comfort or performance. Rebates include energy efficient lighting fixtures, and other equipment.

SMUD Equipment and Energy Star Product Rebates… See SMUD's Web site at www.smud.com.

Appendix D: School District Energy Conservation Financing

California Schools Boards Association, FlexFund Program… Allows districts to save financing costs and achieve lower interest rates through a lease/purchase arrangement for capital projects like copiers, computers, buses, portables and energy equipment.

California Energy Commission, Bright Schools Program… Offers small-to medium-sized public school districts technical assistance to reduce operating costs through energy efficiency. Services include: identification of energy efficiency opportunities, new construction design review, follow-on project installation assistance, evaluation and selection of energy services companies and other contractors, and financing.

California Energy Commission Energy Efficiency Financing Program… Offers loans to school districts, hospitals, cities and other which can finance up to 100 percent of the costs of energy efficiency projects.

A number of California school districts, including Clovis Unified, Los Angeles Unified School District and Live Oak Unified, have already benefitted from these loans.

Standard Performance Contracting (SPC)… A renovation incentive program funded by utility ratepayers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison under the auspices of the California Public Utilities Commission. It offers schools additional financial support for implementing energy efficiency improvement to existing facilities.

Under the program, Energy Efficiency Service Providers (EESPs) provide information and energy audit services to analyze energy saving opportunities in existing school buildings. If energy-efficiency projects are identified, the utility will provide funds to help finance the project in exchange for the energy savings. The utility can make a contract with either the school district or the EESP, depending on how the district wants to manage the project.

SMUD Energy Efficiency Measures Financing… For information on specific financing options and programs, see SMUD's Web site at www.smud.com.

Appendix E: Publications

In addition to the energy efficiency ideas, school districts that are planning to construct new schools, or modernize existing schools need to become familiar with concepts of the California Energy Commission's (CEC) *High Performance Schools Best Practice Manual.* The manual was developed by the Collaborative for High Performance Schools (CHPS), which was established to develop an improved generation of energy efficient, high performance educational environments. The Collaborative is committed to developing and promoting tools, processes, and interventions to deliver sustainable energy efficiency in California K–12 related programs administered by the CEC, please contact Gary Flamm, at 916.654.2817.

There are many State and Consumer Services Agency/Department of General Services' publications that have either been developed or supported over the past several months and include extensive references and documentation of designing energy efficient buildings including:

- *Energy Efficiency and Sustainable Building Measure* – Implementation Procedures, RESD, December 2000.
- *High Performance School Buildings – Resource and Strategy Guide*, sponored by the Collaborative for High Performing Schools (CHPS), Winter 2000.
- *Energy-Efficient Sustainable Schools*, Innovative Design, Inc. with Padia Consulting, Winter 2000.
- *Excellence in Public Buildings – Research Findings and Recommendations*, DSA, January 2001.
- *Sustainable Building Technical Manual, Green Buiding Design, Construction, and Operation*, U.S. Department of Energy and the U.S. Green Building Council, 1998.
- *Blue Print for Sustainable Buildings*, State and Consumer Services Agency; Report to the Governor in Response to Executive Order D-16-00.